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¹ Cf. Warburg, O., *Ergebn. Physiol.*, 14, 1914, (313).

² Haas, A. R., *Science, New York*, N. S., 44, 1916, (105).

³ This did not occur with low concentrations of these substances.

⁴ Osterhout, W. J. V., *Science, New York*, N. S., 35, 1912, (112); *Bot. Gaz., Chicago*, 61, 1916, (148). The determinations referred to in this paper were made in part by Professor Osterhout and in part by me.

⁵ Richards, H. M., *Ann. Bot., Oxford*, 10, 1896, (551). Czapek, F., *Biochemie der Pflanzen*, 2, 1905, (400 ff.).

THE MEANS OF LOCOMOTION IN PLANARIANS

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Communicated by G. H. Parker, October 29, 1917

The ordinary locomotion of fresh-water planarians is of two types, gliding and crawling. True swimming movements are also used by the marine form, *Bdelloura*. When gliding, the planarian slips smoothly and evenly over some supporting surface, with little or no apparent muscular effort. It has been believed generally that this form of locomotion results chiefly, or even entirely from the beating of ventral cilia. Crawling* is accomplished through conspicuous muscular contractions.

Contrary to the opinion frequently expressed in papers on the histology of planarians, all species which I have so far examined have been found to be entirely covered externally with cilia. The cilia on the lateral margins of the anterior region beat in response to very weak stimuli. The cilia over most of the dorsal surface, on the lateral margins other than the head region, and on the ventral surface are usually inactive, except when subjected to strong mechanical or chemical stimuli. Long sensory hairs occur not only in the head region, but along the lateral margins and over the dorsal surface, as well. Tests with powdered carmine show that the ventral cilia of a gliding planarian are not beating during normal locomotion. On the other hand, a planarian when gliding on the under side of the surface film of water, so that the light falls upon its foot at an angle of about 45 degrees, and is reflected to the eye shows delicate muscular waves.

To determine whether locomotion could be accomplished either by the beating of cilia, or by muscular activity alone, a series of tests were made with solutions for the purpose of finding one that would inhibit muscular activity and leave the cilia free to beat normally, and another that would check ciliary action without interfering with muscular contractility. In either case, the animal must remain in all other ways as

nearly normal as possible. Various substances were found to check entirely all muscular activity but leave cilia actively beating all over the body. The most satisfactory results were obtained after one and a half to two and a half hours treatment with a solution of magnesium chloride $m/7$ to $m/9$. When all trace of muscular contractility was lost, locomotion did not occur, even though the cilia were beating with far greater vigor than under normal conditions. A solution of lithium chloride $m/45$, applied for eighteen to twenty-two hours, checks entirely the beat of the cilia, and leaves the muscles sufficiently unaffected to permit of locomotion by gliding. In such tests entire freedom from mechanical vibrations is an absolute essential and care must be exercised in handling the treated specimens to avoid a strong mechanical stimulus.

From these observations I conclude that the locomotion of planarians is essentially a muscular act in which the cilia play no necessary part.

¹ Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College. No. 301.

DIURNAL CHANGES IN THE SEA AT TORTUGAS, FLORIDA

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The only diurnal change noted in the Gulf Stream was a change in temperature of about 1° and the resulting change in oxygen tension. But in water shallow enough for considerable light to reach the bottom, marked diurnal changes were noted in temperature, hydrogen ion concentration (pH), total CO_2 -concentration, CO_2 -tension, O_2 -concentration and O_2 -tension. The temperature, O_2 -concentration and O_2 -tension were lowest and the CO_2 -concentration and CO_2 -tension highest about 5 a.m. The temperature, O_2 -concentration and O_2 -tension were highest and CO_2 -concentration and CO_2 -tension lowest at about 3 p.m., local apparent time during July. The magnitude and exact time of maxima and minima varied somewhat from day to day and varied a great deal with the location of the station at which the water was studied. The diurnal curves showed secondary notches which were probably due to tidal currents and eddies, since no such notches were present in the diurnal curves of stagnant sea water. The differences between stations were evidently due to previous history of the water carried past the station by currents and to variations in depth and in